# Pre AP S'mores Lab
# Limiting Reagents

**Purpose:** To investigate limiting reagent reaction and utilize knowledge of wet lab chemistry to synthesize a delicious treat.

**Introduction:** It is obvious to the most casual observer, that the making of the epicurean delight known as the s'more is not child's play. In fact, it is a study of quantitative relationships involving stoichiometry and should only be undertaken by persons with sufficient training, such high school chemistry students.

Pre-lab Questions:

1. What are the main parts of a written chemical equation?

2. What does the term limiting reagent mean?

3. How is theoretical different from actual yield?

4. How do you think they are both helpful in working with chemical reactions?

5. What is percent yield? (include the equation)

**Advanced Lab Procedures:**
You can use a paper towel as a clean surface for your ingredients.

Step 1) Break your graham cracker into 2 pieces and break your chocolate into 4 pieces. Put your chocolate onto 1 of your graham crackers.

Step 2) Roast your marshmallow over the Bunsen burner with the wood splint – **DO NOT MELT!**

Step 3) Quickly place the marshmallow onto the chocolate pieces and cover it with your second Graham cracker. Wait for it to cool and enjoy the sweet taste of success in chemistry!

**Data:** (draw AND describe the reactants and products)

**Analysis/ Post Lab:**

1. Given 18 squares of Chocolate, how many S'mores can you make if the other ingredients are in excess?

2. If you wished to make 3.5 S'mores, how many Graham Cracker Halves would be needed?

3. Given 7 Graham cracker halves, 2 marshmallows and 20 squares of chocolate:
   a. What is the limiting ingredient?
   b. What is the theoretical yield of S'mores?

4. While doing the experiment described in question 3 above some sugar-starved low life steals some of your ingredients and you are only able to make 2 S'mores. What is your percent yield?

5. At high temperatures, sulfur combines with iron to form the brown-black iron (II) sulfide:

   $$Fe\ (s) + S\ (l) \rightarrow FeS\ (s)$$

   In one experiment, 7.62 g of Fe are allowed to react with 8.67 g of S.
   a. What is the limiting reagent, and what is the reactant in excess?
   b. Calculate the mass of FeS formed.

6. Arcylonitrile, $C_3H_3N$, is the starting material for the production of a kind of synthetic fiber acrylics) and can be made from propylene, $C_3H_6$, by reaction with nitric oxide, NO, as follows:

   $$4\ C_3H_6\,(g) + 6\ NO\ (g) \rightarrow 4\ C_3H_3N\ (s) + 6\ H_2O\ (l) + N_2\,(g)$$

7. What mass of $C_3H_3N$ can be made when 21.6 g of C3H6 react with 21.6 g of nitric oxide?

8. Calculate the percent yield for the reaction: $P_4\,(s) + 6\ Cl_2\,(g) \rightarrow 4\ PCl_3\,(l)$ if 75.0 g of phosphorus reacts with excess chlorine gas to produce 111.0 g of phosphorus trichloride.

9. Formic acid, $HCHO_2$, burns in oxygen to form carbon dioxide and water as follows:

   $$HCHO_2\,(aq) + O_2\,(g) \rightarrow 2\ CO_2\,(g) + 2\ H_2O\ (l).$$

   If a 3.15-g sample of formic acid was burned in 2.0 L of oxygen, what volume of carbon dioxide would be produced? (Assume the reaction occurs at standard temperature and pressure, STP.)

10. Zinc metal reacts with hydrochloric acid to produce zinc chloride and hydrogen gas.
    a. Balance the following reaction: $Zn\ (s) + HCl\ (aq) \rightarrow ZnCl_2\ (aq) + H_2\ (g)$
    b. A 3.50-g sample of zinc metal is allowed to react with 2.50 g of hydrochloric acid.

Complete the following table:

| Reactants/products | Zn (grams) | HCl (grams) | $ZnCl_2$ (grams) | $H_2$ (L) |
|---|---|---|---|---|
| Before reaction | | | | |
| After reaction | 1.26 g | | | |

11. Consider the reaction: $MnO_2 + 4\ HCl \rightarrow MnCl_2 + Cl_2 + 2\ H_2O$
    If 0.45 mols of $MnO_2$ can react with 48.2 g of HCl, how many grams of $Cl_2$ could be produced?

12. One of the components of the fuel mixture on the Apollo lunar module involved a reaction with hydrazine, $N_2H_4$, and dinitrogen tetraoxide, $N_2O_4$. If the balanced equation for this reaction is

    $$2\ N_2H_4\ (l) + N_2O_4\ (g) \rightarrow 3\ N_2\ (g) + 4\ H_2O\ (g),$$

    What volume of $N_2$ gas (measured at STP) would result from the reaction of 1500 kg of hydrazine and 1000 kg of $N_2O_4$? (use 22.4L/mol to convert to volume)

13. Calculate the percent yield for an experiment in which 5.50 g of $SOCl_2$ was obtained in a reaction of 5.80 g of $SO_2$ with excess $PCl_5$. Use the following equation:

    $$SO_2\ (l) + PCl_5\ (l) \rightarrow SOCl_2\ (l) + POCl_3\ (l).$$

14. Chlorine gas reacts with silica, $SiO_2$, and carbon to give silicon tetrachloride and carbon monoxide.
    a. Balance the following equation: $Cl_2(g) + SiO_2(s) + C\ (s) \rightarrow SiCl_4(l) + CO(g)$
    b. How much CO gas can be produced from 15.0 g of silica? (22.4L/mol)

15. When iron (II) hydroxide is mixed with phosphoric acid, iron (II) phosphate precipitate results.
    a. Balance the following equation: $Fe(OH)_2\ (aq) + H_3PO_4\ (aq) \rightarrow Fe_3(PO_4)_2\ (s) + H_2O\ (l)$
    b. If 3.20 g of $Fe(OH)_2$ is treated with 2.50 g of phosphoric acid, what is the limiting reagent and what is the reactant in excess?
    c. How many grams of $Fe_3(PO_4)_2$ precipitate can be formed?
    d. If 3.99 g of $Fe_3(PO_4)_2$ is actually obtained, what is the percent yield?